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Vulcanizable fluororubber composition and process for its production.

A vulcanizable fluororubber composition comprising (A) a fluororubber having vinylidene fluoride units and (B) an organopolysiloxane having amino groups, which form an interpenetrating network structure, wherein at least a part of the fluororubber (A) is chemically bonded to the organopolysiloxane (B), the organopolysiloxane (B) forms a crosslinked structure, and the fluororubber (A) is from 99.5 to 50 parts by weight and the organopolysiloxane (B) is from 0.5 to 50 parts by weight, based on 100 parts by weight of the total of the fluororubber (A) and the organopolysiloxane (B).

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The present invention relates to a vulcanizable fluororubber composition and a process for its production.

Fluororubber is a rubber material provided with heat resistance, oil resistance and weather resistance most excellently and has been effectively used as rubber parts for automobiles, such as oil seals, O-rings and fuel hoses. On the other hand, it has a drawback that it is inferior in the low temperature flexibility.

To solve this problem, various studies have been made on a composition having a silicone rubber excellent in the low temperature characteristics incorporated. By their natures, the fluororubber and silicone rubber have poor affinity to each other, and it has been difficult to obtain a uniform mixture excellent in the processability by mixing them. Nevertheless, in Japanese Unexamined Patent Publications No. 103636/1989 and No. 198646/1989, it is proposed to improve the processability by dispersing the silicone rubber in the form of fine particles by vulcanizing only the silicone rubber at the time of kneading the fluororubber and the silicone rubber.

However, with a blend of such materials which are essentially poor in co-vulcanizability, the physical properties obtainable by the vulcanisation are still inadequate. Although the respective rubber properties are excellent, it has not yet been possible to satisfactory take out and combine such excellent properties of the two.

The present invention has been made with the background of the above-mentioned technical problems of the prior art, and it is an object of the present invention to improve the microscopic dispersibility of fluororubber and silicone by vulcanizing and dispersing the silicone in the fluororubber while chemically bonding the fluororubber and the silicone to form an interpenetrating network structure and to provide a non-vulcanized rubber composition excellent in the processability and free from phase separation and to provide a vulcanizable fluororubber composition excellent in the mechanical strength, heat resistance, cold resistance, oil resistance and weather resistance.

Thus, the present invention has been made to solve the above problems and provides a vulcanizable fluororubber composition comprising (A) a fluororubber having vinylidene fluoride units and (B) an organopolysiloxane having amino groups, which form an interpenetrating network structure, wherein at least a part of the fluororubber (A) is chemically bonded to the organopolysiloxane (B), the organopolysiloxane (B) forms a crosslinked structure, and the fluororubber (A) is from 99.5 to 50 parts by weight and the organopolysiloxane (B) is from 0.5 to 50 parts by weight, based on 100 parts by weight of the total of the fluororubber (A) and the organopolysiloxane (B).

The present invention also provides a process for producing a vulcanizable fluororubber composition, which comprises reacting (A) a fluororubber having vinylidene fluoride units and being substantially not vulcanizable by a peroxide, (B) an organopolysiloxane having amino groups and (C) an organic peroxide at a temperature of at least the decomposition temperature of the organic peroxide (C) while exerting a shear stress.

Now, the present invention will be described in detail with reference to the preferred embodiments.

The fluororubber used as component (A) in the present invention is required to have vinylidene fluoride units. These units react with amino groups of component (B) to chemically bond the fluororubber of component (A) to the organopolysiloxane of component (B). Such units are contained preferably in an amount of at least 10 mol% based on the total constituting units of the fluororubber of component (A). Specifically, it may be a copolymer prepared by copolymerizing vinylidene fluoride with at least one fluorine-containing monomer, or a copolymer obtained by copolymerizing vinylidene fluoride with at least one fluorine-containing monomer and a monomer containing no fluorine.

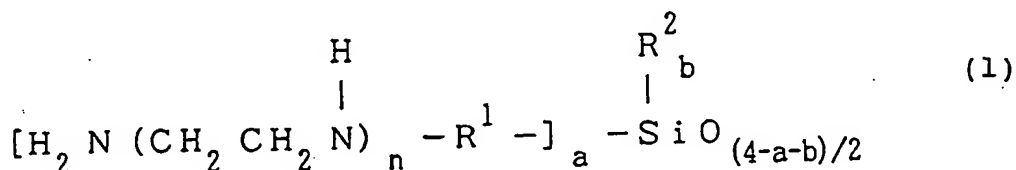
Such at least one fluorine-containing monomer may, for example, be hexafluoropropene, 1,1,1,2,3-pentafluoropropene, 3,3,3-trifluoropropene, tetrafluoroethylene, trifluoroethylene, 1,2-difluoroethylene, dichlorodifluoroethylene, chlorotrifluoroethylene, hexafluorobutene, a vinyl fluoride ether, an alkyl fluoride vinyl ether or a perfluoroacrylate. Particularly preferred are hexafluoropropene and tetrafluoroethylene. The monomer containing no fluorine may, for example, be ethylene, propylene, butene or an alkylvinyl ether. Particularly preferred is propylene.

Specific examples of the fluororubber for component (A) include a vinylidene fluoride-hexafluoropropene copolymer, a vinylidene fluoride-1,1,1,2,3-pentafluoropropene copolymer, a vinylidene fluoride-hexafluoropropene-tetrafluoroethylene copolymer and a vinylidene fluoride-tetrafluoroethylene-propylene copolymer.

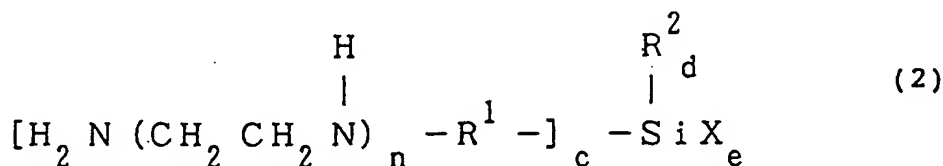
Among these fluororubbers, those vulcanizable by polyols or amines and substantially not vulcanizable by peroxides, are preferred. With fluororubbers vulcanizable by peroxides, fluororubbers tend to vulcanize at the same time as the crosslinking of the organopolysiloxane (B), whereby it sometimes becomes difficult to obtain an interpenetrating network structure, such being undesirable. Further, post processability tends to be poor.

Fluororubbers substantially non-vulcanizable by peroxides are fluororubbers having sites vulcanizable by peroxides, such as carbon-carbon double bonds, iodine or bromine, not introduced.

The organopolysiloxane having amino groups used as component (B) in the present invention, is an essential component to improve the cold resistance of component (A). It may, for example, be an organopolysiloxane of the following formula (1), an organosilane of the formula (2) or a partial hydrolyzate thereof.



wherein R¹ is a valent hydrocarbon group, R² is a substituted or unsubstituted monovalent hydrocarbon group, n is an integer of from 0 to 4, 0 < a ≤ 3, 0 ≤ b < 3, and 0 < a + b ≤ 3.

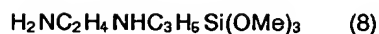
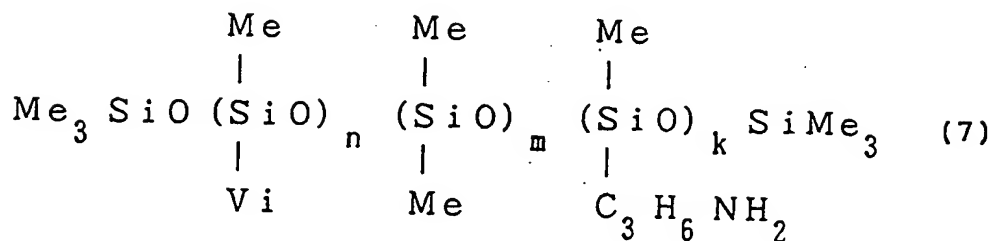
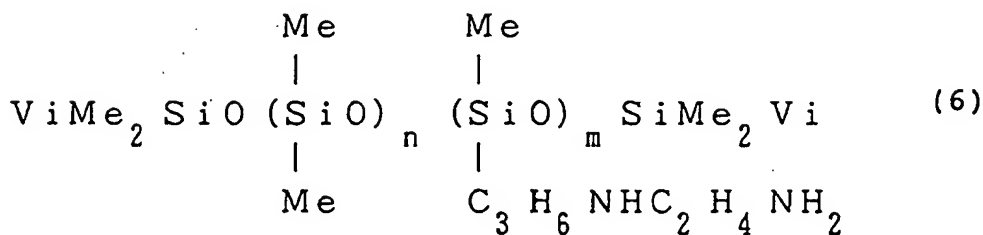
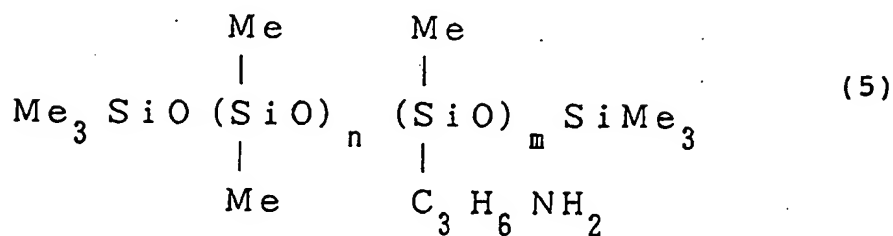
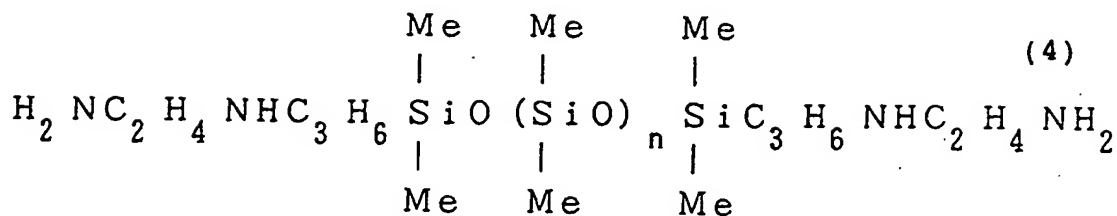
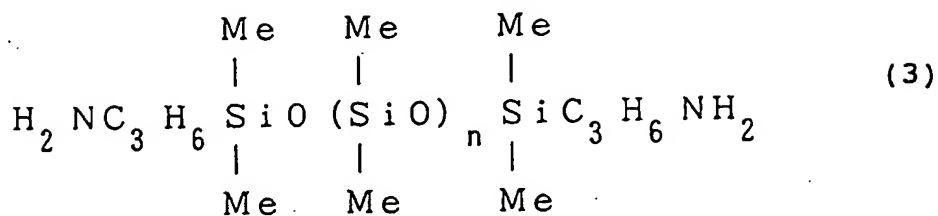


wherein R¹, R² and n are as defined above, X is a hydroxyl group and/or a hydrolyzable group selected from the group consisting of halogen atoms and C₁₋₁₀ alkoxy groups, c is 1, 2 or 3, d is 0, 1 or 2 and e is 1, 2 or 3, provided that c + d + e = 4.

Here, the H₂N(CH₂CH₂NH)_n-R¹- group in component (B) may be the one bonded to a side chain of the silicone or the one bonded to the terminal of the silicone. Component (A) and component (B) are chemically bonded by the reaction of the amino groups in component (B) with the vinylidene fluoride units in component (A), whereby the low temperature characteristics of the fluororubber as component (A) can be improved by component (B) in an amount smaller than the amount required in a case where a simple organopolysiloxane is blended.

When component (A), component (B) and an organic peroxide of component (C) are blended at a temperature of at least the decomposition temperature of component (C), only component (B) will be vulcanized by component (C) and will be uniformly dispersed in component (A) in the form of fine particles (i.e. to form an interpenetrating network structure), whereby a rubber composition having excellent processability can be obtained. To vulcanize and disperse component (B) more effectively, it is preferred to use as component (B) the one having at least one alkenyl group in its molecule.

Specific examples of component (B) include alkoxysilanes of the chemical formulas (3) to (10) and partial hydrolyzates of these alkoxysilanes. They may be used alone or in combination as a mixture of two or more of them.



In the above formulas, Me represents a methyl group, Vi represents a vinyl group, and Et represents an ethyl group.

The amino groups in the organopolysiloxane of component (B) may be primary or secondary amino groups. However, from the viewpoint of the reaction with the fluororubber of component (A), primary amines are preferred. The organopolysiloxane of component (B) may have an optional molecular weight ranging from a liquid having a molecular weight of about 1,000 to a gum having a molecular weight of about 1,000,000.

Further, the organopolysiloxane of component (B) preferably has an amine equivalent of 500 to 100,000. If the amine equivalent is less than this range, the content of amino groups tends to be so large that when reacted with component (A), component (A) tends to be crosslinked, or when component (A) and (B) are kneaded, gelation tends to occur, whereby the processability tends to be poor, and the properties of the vulcanized rubber tend to be poor. If the amine equivalent exceeds 100,000, the reactive sites with the fluororubber tend to be little, and the situation tends to be like a case where a simple organopolysiloxane is mixed, whereby the blend product tends to be poor in compatibility and tends to undergo bleeding out after kneading. The amino groups in component (B) may be in the form of derivatives such as Schiff bases or carbamic acid salts.

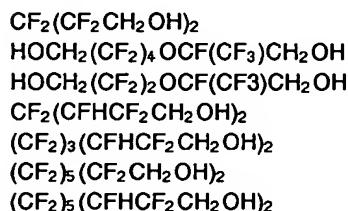
The ratio of component (A) to component (B) is within a range of (A)/(B) = 99.5/0.5 to 50/50. If the proportion of component (B) is less than this range, the effects as component (B) tend to be small, and if it exceeds the above range, the properties of component (A) tend to deteriorate.

The organic peroxide used as component (C) in the present invention is to vulcanize and disperse the organopolysiloxane of component (B) as described above, and it may be any organic peroxide so long as it is capable of generating peroxyradicals under the vulcanization condition. For example, it may be 1,1-bis(5-butylperoxy)-3,5,5-trimethylcyclohexane, 2,5-dimethylhexane-2,5-dihydroxy peroxide, di-t-butyl peroxide, 5-butylcumyl peroxide, dicumyl peroxide, α,α' -bis(t-butylperoxy)-p-diisopropylbenzene, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, 2,5-dimethyl-2,5-di(t-butylperoxy)hexyne-3, benzoyl peroxide, 2,4-dichlorobenzoyl peroxide, t-butylperoxybenzene, 2,5-dimethyl-2,5-di(benzoylperoxy)hexane, t-butylperoxymaleic acid, or t-butylperoxyisopropyl carbonate.

The type and the amount of component (C) are usually selected depending upon the decomposition temperature, the amount of active -O-O-, etc. However, it is used usually in an amount of from 0.1 to 10 parts by weight, preferably from 0.5 to 5 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

To the composition of the present invention, a vulcanizing agent may be blended as component (D) in addition to the above components, to obtain a fluororubber composition. The vulcanizing agent of component (D) is to vulcanize component (A) to obtain a vulcanized rubber. For example, it may be a polyhydroxy compound or a polyamine compound. In each case, a compound useful for polyol vulcanization or amine vulcanization can be used, and a vulcanization accelerator such as an organic onium compound may be used in combination.

The polyhydroxy compound is preferably at least one compound selected from the group consisting of polyhydroxy aromatic compounds and fluorine-containing polyhydroxy aliphatic compounds. The polyhydroxy aromatic compounds may, for example, be bisphenol A, bisphenol AF, resorcinol, 1,3,5-trihydroxybenzene, 1,7-dihydroxynaphthalene, 2,7-dihydroxynaphthalene, 1,6-dihydroxynaphthalene, 4,4'-dihydroxydiphenyl, 4,4'-dihydroxystilbene, 2,6-dihydroxyanthracene, hydroquinone, catechol, 2,2-bis(4-hydroxyphenyl)butane, 4,4-bis(4-hydroxyphenyl)valeric acid, 4,4'-dihydroxydiphenylsulfone, 4,4'-dihydroxydiphenyl ketone, tri(4-hydroxyphenyl)methane, 3,3,5,5-tetrachlorobisphenol A, 3,3,5,5-tetrabromobisphenol A, and 4,4'-dihydroxydiphenyl sulfide. The fluorine-containing polyhydroxy aliphatic compounds may, for example, be the following compounds:



Among these compounds, particularly preferred polyhydroxy compounds are bisphenol AF and hydroquinone, and they may be alkali metal salts or alkaline earth metal salts. These compounds may be used alone or in combination as a mixture of two or more of them. Such a polyhydroxy compound is used usually within a range of from 0.1 to 10 parts by weight, preferably from 0.5 to 5 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

The organic onium compound to be used in combination with the polyhydroxy compound serves as a vulcanization accelerator and is preferably a quaternary ammonium salt or a quaternary phosphonium salt in view of ready availability. Specific examples of such an organic onium compound include tetramethylammonium chloride, tetraethylammonium chloride, tetrapropylammonium chloride, tetrabutylammonium chloride, tetrabutylammonium bromide, tetrabutylphosphonium chloride, benzyltriphenylphosphonium chloride, benzyltriocetylphosphonium chloride and bis(benzylphenylphosphine)iminium chloride. These organic onium compounds may be used alone or in combination as a mixture of two or more of them. Such an organic onium compound is used usually within a range of from 0.05 to 10 parts by weight, preferably from 0.1 to 5 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

In the polyol vulcanization, a metal oxide, a metal hydroxide or a mixture thereof is used as an acid-receiving agent. Specifically, magnesium oxide, lead oxide, calcium oxide, zinc oxide, iron oxide, calcium hydroxide, magnesium hydroxide, lithium hydroxide or a mixture of two or more of them, may be employed. Among them, a combination of magnesium oxide and calcium hydroxide is preferably employed. Such a compound is used usually within a range of from 0.5 to 30 parts by weight, preferably from 1 to 20 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

The polyamine compound may, for example, be hexamethylenediamine, N,N'-dicinnamylidenehexamethylenediamine or hexamethylenediamine carbamate, and it is used usually within a range of from 0.3 to 10 parts by weight, preferably from 0.5 to 5 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

In the amine vulcanization, like in the polyol vulcanization, a metal oxide used for the polyol vulcanization, may be used as an acid-receiving agent. Among them, magnesium oxide is preferably used. Such an acid-receiving agent is used usually within a range of from 0.5 to 40 parts by weight, preferably from 1 to 30 parts by weight, based on 100 parts by weight of the total of components (A) and (B).

To the fluororubber composition of the present invention, other components including a filler or a reinforcing agent, such as carbon black, silica, clay, diatomaceous earth, calcium carbonate or barium sulfate, a processing assistant, a plasticizer, an internal releasing agent and a colorant, may be incorporated, as the case requires.

The fluororubber composition of the present invention can be prepared by reacting components (A), (B) and (C) at a temperature of at least the decomposition temperature of component (C) while exerting a shearing force, then cooling the mixture and adding component (D) at a temperature of not higher than the vulcanization temperature of component (A). This operation can be conducted by means of a Banbury mixer, a kneader, a press kneader or a twin roll mill.

The fluororubber composition thus obtained may be vulcanized and molded by a conventional method such as compression molding, injection molding, extrusion molding or calender molding.

The vulcanizable fluororubber composition of the present invention is believed to have excellent processability, low temperature flexibility and vulcanization properties, since the amino group portion in the organopolysiloxane having amino groups is reacted and chemically bonded to the vinylidene fluoride unit portion in the fluororubber, and the organopolysiloxane is dispersed in the fluororubber while being vulcanized by the organic peroxide.

Now, the present invention will be described in further detail with reference to Examples. However, it should be understood that the present invention is by no means restricted by such specific Examples. In the following Examples, "parts" means "parts by weight".

The properties of the vulcanized rubber were measured in accordance with JIS K-6301.

EXAMPLES 1 TO 5

In accordance with the composition shown in Table 1, the fluororubber, the organopolysiloxane having amino groups, the carbon and the organic peroxide were reacted under kneading at 170 °C for 15 minutes by a kneader, and then the mixture was taken out, cooled and then wound on a twin roll, whereupon magnesium oxide, calcium hydroxide, bisphenol AF and the organic onium compound were added to obtain a fluororubber composition. At that time, the rolling efficiency was examined. This fluororubber composition was subjected to press vulcanization at 170 °C for 10 minutes and secondary vulcanization at 230 °C for 24 hours to examine the vulcanization properties. The results are shown in Table 1.

COMPARATIVE EXAMPLES 1 TO 3

The respective fluororubbers used in the preceding Examples were formed into rubber compositions by a twin roll without using the organopolysiloxane and the organic peroxide and without heating, and the

rubber compositions were vulcanized by conventional polyol vulcanization. The results are shown in Table 1. The vulcanization conditions were the same as in the preceding Examples.

COMPARATIVE EXAMPLE 4

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In accordance with the composition as shown in Table 1, a rubber composition was prepared and vulcanized in the same manner as in Examples 1 to 5. However, for the purpose of comparison, an organopolysiloxane having no amino group was employed. The rolling efficiency and the vulcanisation properties were examined, and the results are shown in Table 1.

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COMPARATIVE EXAMPLE 5

In accordance with the composition as shown in Table 1, a rubber composition was prepared and vulcanized in the same manner as Examples 1 to 5. However, for the purpose of comparison, no organic preoxide was employed. The rolling efficiency and the vulcanization properties were examined. The results are shown in Table 1.

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COMPARATIVE EXAMPLE 6

A rubber composition was prepared and vulcanized in the same manner as in Comparative Example 4 except that no organic peroxide was used. The rolling efficiency and the vulcanization properties were examined. The results are shown in Table 1.

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Table 1

	Examples						Comparative Examples					
	1	2	3	4	5		1	2	3	4	5	6
Fluororubber 1	100			100	100		100	100		100	100	100
Fluororubber 2		100										
Fluororubber 3			100						100			
Organopolysiloxane 1	10				5						5	
Organopolysiloxane 2		5										
Organopolysiloxane 3			15									
Organopolysiloxane 4				20								
Organopolysiloxane 5										10		10
MT carbon	25	25	25	25	25		25	25	25	25	25	25
Organic peroxide 1	1.5	1.5	1.5	1.5						1.5		
Organic peroxide 2					1.5							
Magnesium oxide	3	3	3	3	3		3	3	3	3	3	3
Calcium hydroxide	6	6	6	6	6		6	6	6	6	6	6
Bisphenol AF	2	2	2	2	2		2	2	2	2	2	2
TBPCl	0.8	0.8		0.8	0.8		0.8	0.8	0.8	0.8	0.8	0.8
TBPCl			1									

Table 1 (continued)

	Examples					Comparative Examples					
	1	2	3	4	5	1	2	3	4	5	6
Rolling efficiency	○	○	○	○	○	○	○	○	○	△	×
<u>Vulcanization properties</u>											
Hardness	60	64	60	58	65	74	73	75	70	73	74
100% Modulus (kg·f/cm ²)	45	52	38	35	56	73	70	85	56	70	88
Tensile strength (kg·f/cm ²)	125	145	122	111	150	70	162	180	110	165	145
Elongation (%)	260	220	290	230	210	20	220	200	190	210	180
<u>Low temperature characteristics</u>											
TR-10 (°C)	-22	-23	-17	-29	-19	-16	-19	-7	-19	-19	-18
<u>Volume swelling (%)</u>											
FUEL D (40°C, 70 Hr)	14	10	44	23	9	4	3	30	17	9	19

The rolling efficiency in Table 1 was evaluated by the following standards.

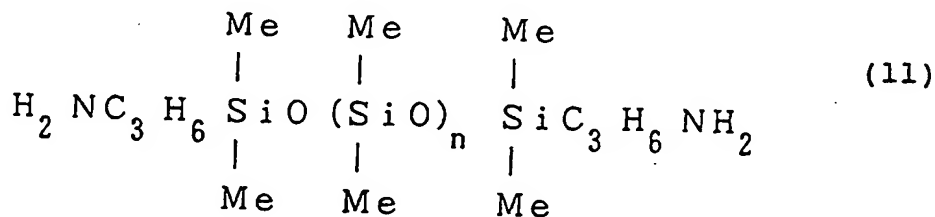
○ : The rubber composition was wound on the rolls within 30 seconds and remained to be wound thereon even when the gap between the rolls was widened so that no bank was present.

△ : The rubber composition was wound on the rolls within 30 seconds but released from the rolls when the gap of the rolls was widened so that no bank was present.

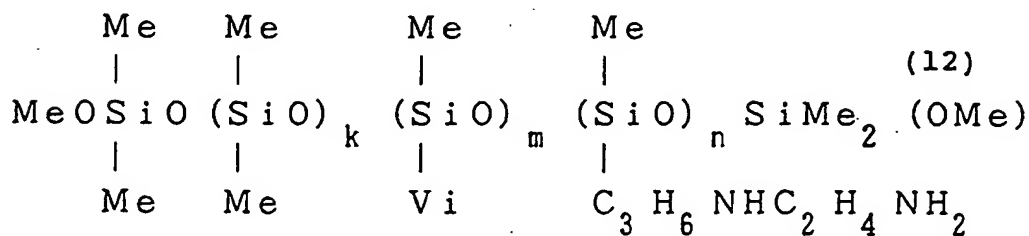
x : The rubber composition was hardly wound on the rolls, and the wound rubber composition was readily released from the roll when the gap of the rolls was widened.

The fluororubbers 1, 2 and 3 used in Examples and Comparative Examples are a copolymer of vinylidene fluoride/hexafluoropropylene = 78/22, a copolymer of vinylidene fluoride/hexafluoropropylene/tetrafluoroethylene = 78/16/6 and a copolymer of vinylidene fluoride/tetrafluoroethylene/propylene = 35/40/25, respectively.

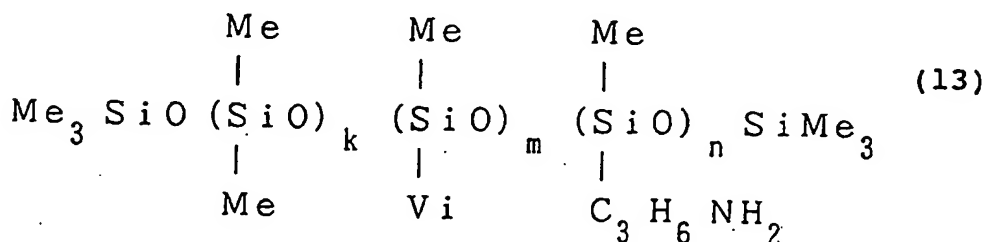
Organopolysiloxanes 1, 2, 3, 4 and 5 are compounds of the formulas (11), (12), (13), (14) and (15), respectively.



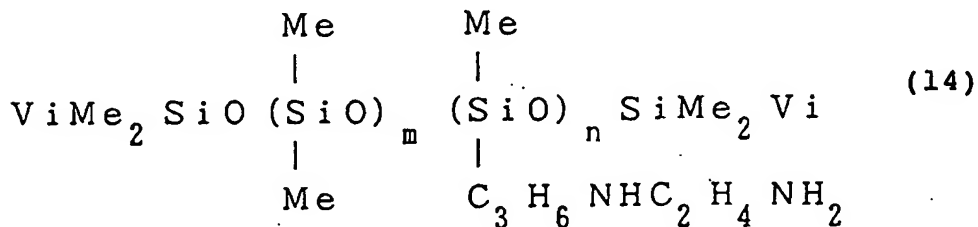
(amine equivalent: 3,000)



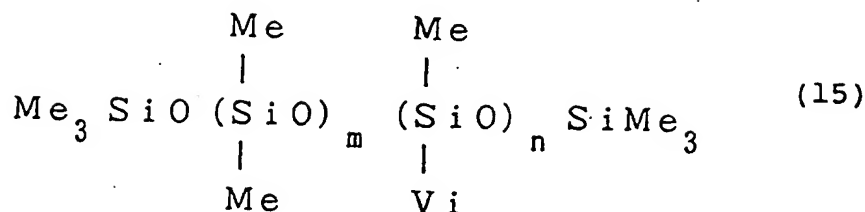
(amine equivalent: 3,000, vinyl equivalent: 3,000)



(amine equivalent: 10,000, vinyl equivalent: 15,000)



(amine equivalent: 3,000, vinyl equivalent: 6,000)



(vinyl equivalent: 10,000)

Organic peroxide 1 is dicumyl peroxide; organic peroxide 2 is α,α' -bis(t-butylperoxy)-p-diisopropylbenzene; TPBPCI is triphenylbenzylphosphonium chloride; and TBPCI is tetrabutylphosphonium chloride.

COMPARATIVE EXAMPLE 7

In accordance with the same composition as in Comparative Example 1, the fluororubber, the organic silicoine compound, the carbon and the organic peroxide were kneaded for 15 minutes at a temperature of not higher than 70°C under cooling by means of a kneader, and the mixture was heated in a stationary state at 170°C for 15 minutes. After cooling, the mixture was taken out and wound on a twin roll. Then, it was attempted to incorporate magnesium oxide, calcium hydroxide, bisphenol A and the organic onium compound, but due to gelation, it was impossible to uniformly add these materials and it was impossible to conduct vulcanization.

The vulcanizable fluororubber composition of the present invention has excellent properties of fluororubber and excellent low temperature characteristics of silicone and thus has a wide range of applications, and it can easily be produced. Thus, it is very useful from both industrial and economical viewpoints.

Claims

1. A vulcanizable fluororubber composition comprising (A) a fluororubber having vinylidene fluoride units and (B) an organopolysiloxane having amino groups, which form an interpenetrating network structure, wherein at least a part of the fluororubber (A) is chemically bonded to the organopolysiloxane (B), the organopolysiloxane (B) forms a crosslinked structure, and the fluororubber (A) is from 99.5 to 50 parts by weight and the organopolysiloxane (B) is from 0.5 to 50 parts by weight, based on 100 parts by weight of the total of the fluororubber (A) and the organopolysiloxane (B).
2. The vulcanizable fluororubber composition according to Claim 1, wherein the chemical bond is a chemical bond between the vinylidene fluoride units of the fluororubber (A) and the amino groups of the organopolysiloxane (B).
3. The vulcanizable fluororubber composition according to Claim 1, wherein the organopolysiloxane (B) has a crosslinked structure formed by an organic peroxide.
4. A fluororubber composition having a vulcanizing agent incorporated to the vulcanizable fluororubber composition of Claim 1.
5. The fluororubber composition according to Claim 4, wherein the vulcanizing agent is the one selected from the group consisting of polyhydroxy compounds and polyamine compounds.
6. A process for producing a vulcanizable fluororubber composition, which comprises reacting (A) a fluororubber having vinylidene fluoride units and being substantially not vulcanizable by a peroxide, (B) an organopolysiloxane having amino groups and (C) an organic peroxide at a temperature of at least the decomposition temperature of the organic peroxide (C) while exerting a shear stress.
7. The process according to Claim 6, wherein after reacting the fluororubber (A) and the organopolysiloxane (B), the organic peroxide (C) is added thereto, the temperature is raised to a level of at least the

decomposition temperature of the organic peroxide (C).

8. A method for vulcanizing a vulcanizable fluororubber composition, which comprises reacting (A) a fluororubber having vinylidene fluoride units and being substantially not vulcanizable by a peroxide, (B) an organopolysiloxane having amino groups and (C) an organic peroxide at a temperature of at least the decomposition temperature of the organic peroxide (C) while exerting a shear stress to obtain a vulcanizable fluororubber composition, then incorporating a vulcanizing agent thereto, and vulcanizing the mixture.

9. The vulcanizing method according to Claim 8, wherein the vulcanizing agent is incorporated at a temperature of not higher than the vulcanizing temperature of the component (A)

10. The vulcanizing method according to Claim 8, wherein the vulcanizing agent is the one selected from the group consisting of polyhydroxy compounds and polyamine compounds.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 12 0112

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,X	EP-A-0 485 906 (ASAHI GLASS COMPANY) * page 6, line 54 - page 7, line 29 * * examples * * claims 1-10 * ---	4-7	C08L27/16 C08L83/08 C08G81/02 //(C08L27/16, 83:08) (C08L83/08, 27:16)
X	EP-A-0 338 393 (KIMBERLEY-CLARK CORPORATION) * page 13, line 5 * * claim 1 * ---	1	
A	DE-A-2 519 964 (DAIKIN KOGYO) * claims 1,5,7-10,12,15 * -----	1-4,6-9	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C08L C08G C08K
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 18 FEBRUARY 1993	Examiner SIEMENS T.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	